UNITED STATES MARINE CORPS

LESSON PLAN

LOCAL CIRCULATIONS

INTRODUCTION:

1. Gain Attention. Who can tell me what region in the United States produces the most lightning? Can you narrow it down to which state produces the most lightning? Why do you think this state produces such an abundant amount of lightning?

INSTRUCTOR NOTE: The state of Florida produces the most lightning within the United States due to converging sea breezes.

2. Overview. During this period of instruction, the student shall be introduced to the local patterns that affect various locations throughout the world.

3. Introduce Learning Objectives.

a. Terminal Learning Objective. Without the aid of references, but in accordance with the period of instruction, define and discuss the various localized wind systems.

b. Enabling Learning Objective(s). In accordance with this period of instruction, complete the following tasks:

(1) State the difference between on/off shore flow and land/sea breezes.

(2) State the time of day and season that the various local wind patterns are most likely to be in effect.

(3) Provide general knowledge of various locations where local wind systems are common.

4. Method/Media. This period of instruction will be taught using the lecture method with aid of QMMCBT-001 "Introduction to the Dynamics of the Atmosphere".

5. Evaluation. You will be evaluated by verbally demonstrating the fundamental types and concepts of local wind systems.

TRANSITION. We have already discussed the causes of the global wind circulation about the Earth, as well as, the Macroscale wind flow patterns and pressure systems and how they dictate large-scale wind flow patterns. However, various locations also experience synoptic to mesoscale wind patterns that affect the regions climate.

BODY:

1. Land and Sea Breezes. The daily temperature changes and resulting pressure gradients are what ultimately cause land and sea breezes.

a. Sea Breeze.

(1) During the day, the land heats at a greater rate than does the ocean. This is due to their abilities to hold heat (refer to QMMPH1-013 "Heat and Energy" for a review of specific heat).

(2) As a result, the land will heat and expand, resulting in an area of lower pressure. This area of lower pressure, in turn, then creates a *sea breeze* as cooler air over the water moves on land to replace the warm rising air.

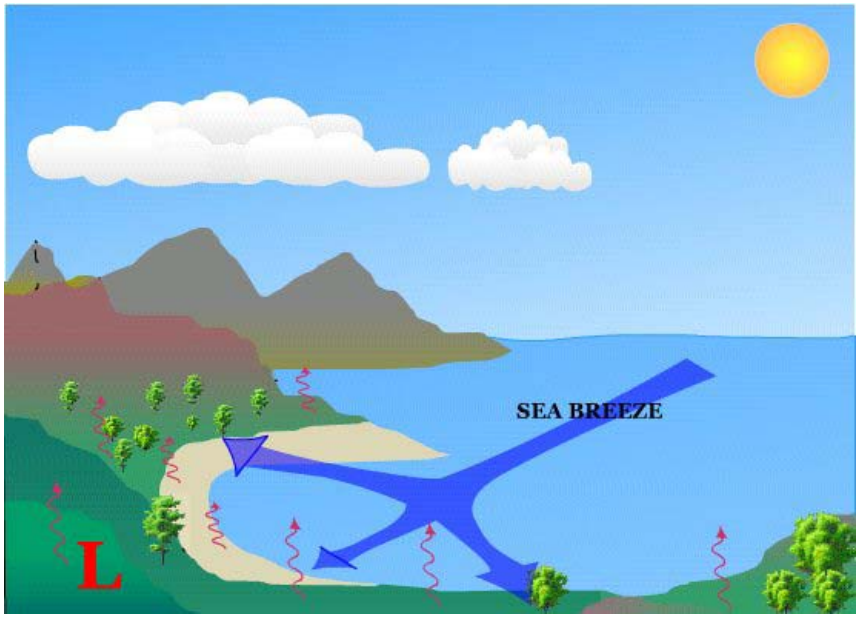

Figure 1 – Surface heating over the land causes cooler air from the ocean to flow inland and replace the rising warmer air creating a sea breeze.

b. Land Breeze.

(1) During the night, the land cools at a greater rate than does the ocean. Again, due to their respective abilities to maintain heat.

(2) As a result, the land will cool more rapidly than the water producing the opposite affect of a sea breeze. Relatively lower pressure is now located over the ocean. This area of lower pressure, in turn, then creates a *land breeze* as cooler air over the land moves offshore to replace the warm rising air over the ocean.

Figure 2 – At night the land cools more quickly and cooler from will flow offshore to replace the warmer rising creating the land breeze.

c. Effects of Sea and Land Breezes.

(1) Sea breezes have significant results on moderating coastal temperatures. After the onset of a sea breeze, land temperatures may drop by as much as 5-10°C.

(2) However, this cooling affect reaches a maximum of approximately 60 miles inland from the coasts. Sea breezes usually begin just before noon, reach their maximum intensity of 8 to 15 knots, and then begin to weaken with sunset. The strength of the sea breeze will be directly related to the temperature difference between the land and sea.

(3) The intensity and extent of the land and sea breezes also depends on the location and the time of year.

1. Tropical areas, where intense solar heating takes place takes place year round; experience more frequent and stronger sea breezes than mid-latitude locations do. The most intense sea breezes develop along tropical coastlines that reside along cold ocean currents (providing for a great temperature, hence pressure difference).

2. In the middle latitudes, sea breezes are most common during the warmer summer months, but the land breeze may often be missing because the land may not always cool to or below the ocean (or lake) temperature.

3. In the higher latitudes, sea and land breezes are often absent due to the frequent passage of low and high-pressure systems that dominate the circulation. In short, land and sea breezes are most common when there is no synoptic gradient present.

2. Mountain and Valley Breezes. A daily wind that is similar to sea and land breezes occur in mountainous terrain.

a. Valley Breeze. During the day with the solar heating from the Sun, air along the mountain slopes is heating more rapidly than the air at the base of the mountain, or valley floor. This warmer air glides up the mountain slopes generating a *valley breeze*.

(1) One can often identify the upslope breezes by the isolated cumulus clouds that tend to develop over the mountain peaks and may often cause late afternoon showers or isolated thunderstorms.

(2) Valley breezes are most common during the warmer months when solar heating is most intense.

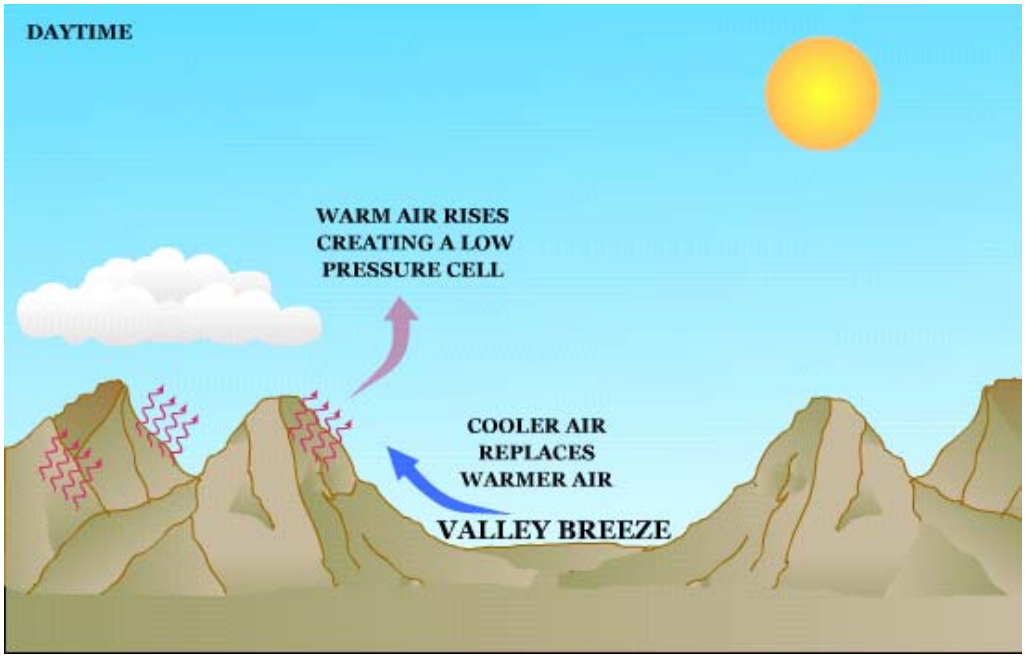

Figure 3 – During the day the mountain slopes heat faster than the valley floor.

b. Mountain Breeze.

(1) After sunset, the patterns reveres, and the rapid radiation heat, that was once the source of energy is no longer into play, and acts to cool the mountain slopes. This cooler, more dense air then glides down the mountain slope into the valley as a *mountain breeze*.

(2) Mountain breezes tend to be more frequent during the cold months when colder temperatures are dominant.

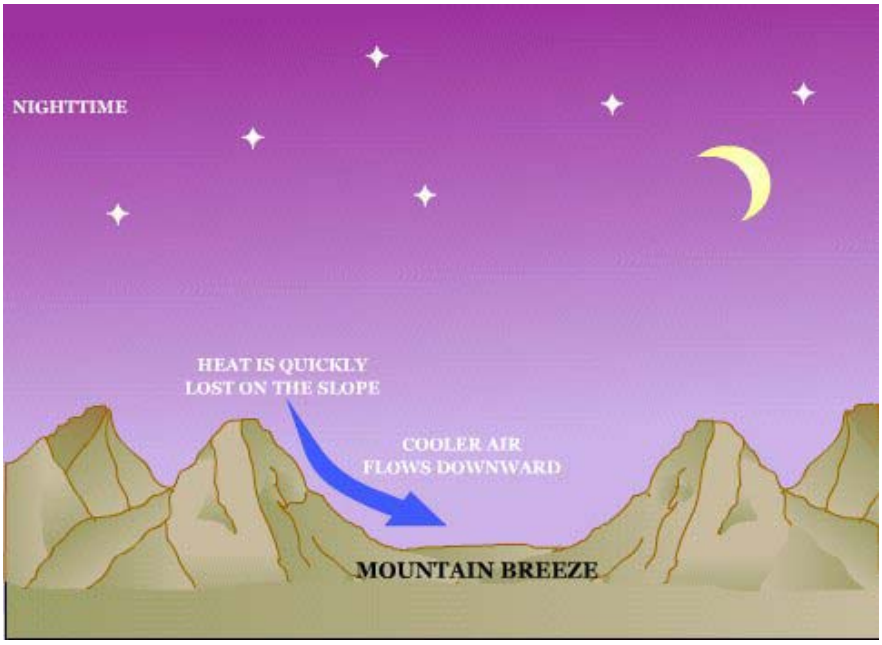

Figure 4 – At night, the slopes cool faster than the valley floor creating a downsloping wind.

3. Foehn/Chinook Winds. These winds are downslope winds. The difference between the two names is locations. "Foehn" (pronounced as in *fern* with a silent "r") is used in the Alps, while "Chinook" is used is the Rocky Mountain Range.

a. This type of wind occurs when a steep pressure gradient develops with high pressure on the windward side of a mountain and low-pressure system or trough on the leeward side of the mountain.

b. Air will ascend down the gradient, from higher to lower pressure (windward to leeward).

c. The air flowing down the leeward side of the mountain is dry and warm. The wind will lose its moisture on the windward side through latent heat of condensation in the form of rain or snow.

d. As the wind blows down the leeward side, it warms further adiabatically and arrives at the base of the mountain as a warming, drying wind.

e. Foehn or Chinooks producing remarkable rises in temperatures leeward of the mountain in just a few minutes.

f. At the Rocky mountain front, it is know as a "snow eater" because the winds will rapidly the melt the snow and commonly dries the mud underneath it.

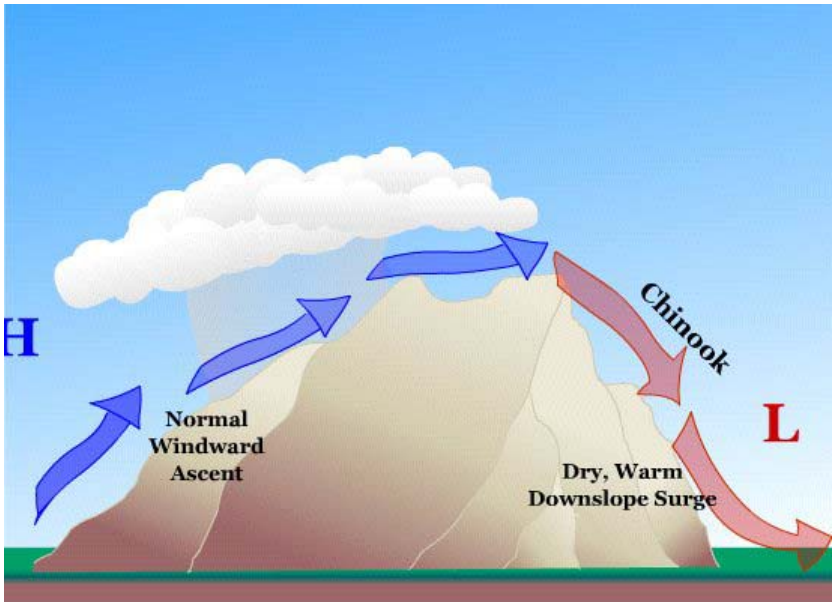

Figure 5 – Downward winds on leeside and adiabatic warming creates a strong dry, warm wind.

4. Onshore and Offshore Winds.

a. An onshore wind flow will occur when the synoptic scale pressure gradient allows for wind flow from the water to the land surface.

(1) Friction increases as the wind flows onshore. This will cause the wind to slow in speed and back (counterclockwise) in direction.

(2) Low-level convergence occurs along the coastline as air accumulates.

b. An offshore wind flow will occur when the synoptic scale pressure gradient allows for the wind to flow from land to water.

(1) As air flows offshore, friction will decrease causing an increase in wind speed and a veering (clockwise rotation) or wind direction.

(2) This leads to low-level divergence along the coastline.

c. A significant type of onshore and offshore flow that occurs on a seasonal basis is a *monsoon*. Monsoons are seasonal reversals of wind patterns that are often caused by unequal heating between landmasses and the oceans.

TRANSITION: Localized wind flow patterns affect each region or location differently based on the topography and climatology of that area.

OPPORTUNITY FOR QUESTIONS:

1. Questions from the Class. At this time, are there any questions pertaining to the material that was just presented to you?

2. Questions to the Class.

a. QUESTION. Describe the difference between land/sea breezes and on/offshore wind flow patterns?

b. ANSWER. Unequal heating of the land and ocean causes Land and sea breezes. On/offshore winds are winds that are gradient induced from synoptic scale pressure systems.

REFERENCE.

Lutgens, Frederick K. and Tarbuck, Edward J. The Atmosphere, An Introduction to Meteorology. 9th edition. Pearson Education Inc, 2004.

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